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RESPONSE OF COWPEA (*Vigna unguiculata* L.*)* TO IRRIGATION WATER DEFICIT AT DIFFERENT GROWTH STAGES IN SEMI-ARID, NIGERIA

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ABSTRACT
Field experiments were conducted during the 2007/2008 dry season farming in Maiduguri, Borno state; in the northern Sahel savanna agro-ecological zone of Nigeria to evaluate the effect of imposing a 50% irrigation water deficit at different stages of growth of cow pea (*Vigna unguiculata* L*)* on growth and yield of the crop. The experiment was laid out in a randomized complete block design with three replications using basin irrigation system. The results indicated that the reduction in 50% of irrigation water requirement had affected the both the growth and yield of the crop. It also showed that water savings are possible without significant effect on the growth and yield of the crop at stages 1, 2, 4 and 1&4. Applying the same water stress at two or more stages of growth of the crop has a detrimental consequence.

KEYWORDS: irrigation, water stress, growth stages, cowpea, semiarid region.

INTRODUCTION

Cowpea (*Vigna Unguiculata L.*) is a tropical crop which grows erect, prostrate or climb. it grows successfully on great varieties of soils. Cowpea could complement a large number of other food crops by utilization of two different edible plant parts (leave and seeds). It is one of the versatile legume crops that can provide high protein and carbohydrate together with moderate protein and low fat from foliage as well as seeds for a vegetarian diet in a space-deployed bioregenerative life support system and could therefore play an important role in solving the problems of malnutrition, especially in countries suffering from hunger and poverty that usually characterizes countries where food production has not kept pace wit their food demand.

Irrigation water deficit (IWD) could be summarily defined as a temporary practice of supplying water to crops at rates lower than the actual crop water requirement for a predetermined period of time and/or degree of severity. The deficit is created either by supplying a pre-calculated amount of water lower than the calculated crop water requirement, or by extending the irrigation interval. In a way, it is deliberate means of subjecting crop to some degree of moisture stress. The merits and demerits of IWD were elaborated by Garrity et al. (1982); Rodrigues et al. (2007); Ma et al. (2007); Ewemoje (2007); and Deng et al. (2006). The influence of moisture stress on crop yield is a complex factor depending on duration, intensity, frequency and timing of stress, genotype and environmental factors (Mudiare and Bungwon, 2002). But shortage of water is the most important and limitation for crop production, especially in the arid and semi-arid regions of the world. Therefore competition for the limited water supplies has been on the increase. Irrigation water is consequently becoming increasingly scarce and expensive, most especially in the face of the present global warming with consequential effects of decreased precipitation, increase of temperature, among others. Crop water deficit may not therefore be totally avoided, but instead be controlled, to allow for better economic utilization of limited available water resources and to derive optimum benefit from the land and water.

The critical stages of moisture are commonly used to define stages of growth at which plants are most sensitive to water stress. Each crop has certain critical stage at which if it experiences moisture stress beyond a threshold, its yield could be reduced dramatically (Michael, 1998). The requirement regarding the number of irrigation and their timing vary widely for different crops and with stages of its growth i.e. initiation, development, early maturity and late season (Richard et *a.*, 2005). When water supply is limited, it is necessary to take into account the critical stage(s) of crop growth with respect to moisture supply.

Cowpea may show some phenotypic response to water stress, but most irrigation farmers do not consider the stages of growth at which the crop needs water most to sustain its growth. It is therefore, essential to study these stages so that farmers would be informed appropriately, so that they will use the limited available water in a judicious manner.

Irrigation in the northern Nigeria has a long history, but the farmers generally lack the basic knowledge of crop water requirement irrigation skill. As a result, water application had been haphazard with no specific irrigation interval. This could result in over- or under-irrigation both of which could translate to wastage of the limited water resources, flood, soil salinization, yield depression, and, hence, farmers' economic distress (James, 1988; Mouromical and Ierna, 1995; Shock, 2002). Doorenbos and Pruitt (1984) also reported that over-irrigation could lead to poor yields. The distribution of rain fall in this region is uneven, both in space and time, and does not therefore optimally support crop growth that would ensure food sufficiency for the ever growing population in Nigeria. IWD in northern Nigeria could therefore be a vital tool in water management.
The objective of this study was to assess the effect of irrigation water deficit during growth stages on the growth and yields of cowpea.

MATERIALS AND METHODS

The experiment was carried out in the dry season of year 2007 in Maiduguri (11.5^{o}N, 13.5^{o}E), the Borno State capital city in the semi-arid zone of the northern Sahel savannah, Nigeria. No rainfall was recorded during the period of the study. Table 1 presents some of the physical properties of the soil in the study area. The treatments used in the study were basically withholding 50% of the crop irrigation water requirement at each growth stage of cowpea, thereby imposing 50% water stress during these stages (Table 3). NS represented non-stressed plots where full irrigation (100%) of net water requirement (NWR)) was applied and was used as the control.

Each experimental plot was 25m^2 (5mx5m), replicated three times laid in a randomized complete block design (RCBD). A 0.75m-wide ridge was used to separate between the plots and two buffer ridges to separate between replications. A total of 36 plots were used for the study on a 0.1 ha field using basin irrigation system.
"SS" means a 50% water stress was imposed in the stage indicated by subscript following SS (Table 3). The treatments were imposed on the plants exactly 14 days after sowing.

The Maiduguri water treatment plant popularly known as *mothercat* was relied upon for the supply of water for the irrigation. Irrigation water was allowed to flow into the plots at 2 l/sec to minimize possibility of erosion hazards and to achieve better irrigation uniformity (James, 1988).

The crop water requirement of the crop and the water flow rate in canals were calculated following the method of James (1988). Parameters determined in the overall research include growth parameters (plant height, numbers of leaves per plant, leaf area per plant) and yield and yield components (numbers of branches per plant, numbers of pods per plant, seed weight, 100 seed weight, and grain yield)

The grain yield was obtained from each plot by harvesting and threshing the crop in each plot manually and then weighing the grain obtained there from using an electronic balance. The same type of balance was used in all other weighing.

Growth parameters were recorded weekly from week 2 (14 days) after sowing (AS) when 98% germination was recorded. All data recorded were subjected to analysis of variance (ANOVA) using the F-test as described by Gomez and Gomez (1984). Differences among the treatments and any interaction(s) were separated using the Duncan's Multiple Range Test (DMRT).

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RESULTS AND DISCUSSIONS

Growth Parameters

Plant heights

The heights of the plants were generally statistically (P=0.05) similar in week 2 after sowing respectively (Table 4). This was attributed to the fact that the treatments were just imposed on the plants and only the plants that belong to treatments SS1 had received their treatment, and thus no visible difference was observed. A similar trend was observed in week 3 AS. The real effects of the treatments were noticed from week 4 AS. Applying the 50% of the net irrigation water requirement at stages 2, 1&2, 1&3, and 1,2,3,&4 had significantly (P=0.05) affected the heights of the plants (Table 4).

The heights of plants stressed at stages 1 and 4 only were statistically similar to the heights of the non stressed plants (NS). Generally, on average, the tallest plants were the non-stressed plants and they were closely followed by those plants that received stress treatments at stages 1, 4, and 1&4 only respectively. Plants that were stressed at all their stages of growth (stages 1,2,3,4) were the shortest throughout the period of the study.

Number of leaves

A significant variation (P=0.05) was observed among the stressed plants with regards to their numbers of leaves in all the weeks during the growth of *Vigna Unguiculata L.* It was observed that plants that were stressed at stages 1&3, 2&3, 2&4 and 1,2,3,4 suffered the lowest numbers of leaves (Table 5).Yes, it is true that their heights were similar in weeks 2 and 3 (Table 4), but their leaves were few and tiny. However, the numbers of leaves of plants that were stressed at stage 1 and stage 4 were statistically at par with that of the n on-stressed plants (Table 5). This result is similar to the findings of Chaturvedi *et al*. (1980), Bubenheim *et al*. (1990) and Singh *et al*. (1997). There was a drastic drop in the numbers of leaves of plants stressed at stage 1 and then at stage 3 (SS1 and SS3), this was because these plants suffered stress at stage 1 (initiation stage) and then at stage 3 (mid season stage), and this results was not different from those SS2,4; SS3,4; and SS1,2,3,4. Evidently, stressing *Vigna Unguiculata L.* at more than one stage translated to be having detrimental effects.

Leaf Area

The effect of moisture stress at different growth stages of *Vigna Unguiculata L.* had significantly (P=0.05) affected the leaf area per plant. All plants that received water stress at stage 1, stage 2, or stage 4 had a similar leaf area per plant (Table 6). The leaf area per plant of the non stressed plants were however higher. Applying water stress at stage 3 (SS3) of growth had translated to a significant depression in stage 3 is mid-season, and obviously plants need adequate water supply.

Plants that were stressed at two different stages of their growth exhibited a very low leaf area per plant. It follows that a plant could be tall or long as the case may be, and may have many leaves, but can have small leaf area, as depicted by plants that were stressed at stages 1&4. It points that such plants has not been growing well, apparently due to the imposed water stress.

Yield and yield components

The number of branches, number of seed/plant, seed weight/plant, 100-seed weight and grain yield that are the yield components of *Vigna Unguiculata L.* were all affected by the treatments applied on the plants (Table 7). In all respects, however, the non-stressed plants exhibited best performance. All the values of the yield and yield components recorded for the non-stressed plants were however statistically similar with the plants that received water stress at only stage 1, or 2 or 4. The number of branches/plant and number of pod/plants of the plants stressed at stages1 and then at stage 4 were at par with those obtained from the non-stressed plants. But their seed weight, 100-seed weights and grain yield were lower (Table 7)

CONCLUSION

Results obtained from the study showed that imposing water stress at stage(s) 1, 2, 4 and 1&4 during the growth of *Vigna Unguiculata* does not induce reduction in growth and/or yield of the crop. This provides an opportunity of safely saving up 50% of irrigation water at these stages of growth, and could help in reducing water waste, thereby maximizing the benefits from unit volume of water. Applying full irrigation at all stages of growth is no longer necessary. This study, however, cautioned against imposing up to 50% irrigation water stress on the crop at two or more stages (other than stages 1&4) as doing so had translated in retardation in growth with corresponding remarkable reduction in yield. It is thus a detrimental practice, possibly due to the prevailing climate.

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Table 1: Some physical properties of the soil used in the study

Parameter	Value
Sand (2-0.05mm) (%,w/w)	77
Silt (0.05-0.002 mm)(%, w/w)	16.6
Clay (<0.002 mm) (%, w/w)	6.4
Texture	Sandy loam
Field capacity (%, w/w)	20.7
Permanent wilting point (%, w/w)	9.5
Infiltration rate ($cmhr^{-1}$)	2.5
Dry bulk density ($Mgcm^{-3}$)	1.65
Saturated hydraulic conductivity (mmhr-1)	25.2
Soil saturation (%)	45.3

Table 2: Crop growth stages and durations for cowpea

Stage	Name	Duration (days)
1	Initiation	20
2	Development	30
3	mid-season	30
4	Late-season	20
Total		110

Table 3: Treatments given during the growth of cowpea

Stages of growth	1	2	3	4
Treatments				
NS	1	1	1	1
SS_1	½	1	1	1
SS_2	1	½	1	1
SS_3	1	1	½	1
SS_4	1	1	1	½
$SS_{1,2}$	½	½	1	1
$SS_{1,3}$	½	1	½	1
$SS_{1,4}$	½	1	1	½
$SS_{2,3}$	1	½	½	1
$SS_{2,3}$	1	½	1	½
$SS_{3,4}$	1	1	½	½
$SS_{1,2,\ 3,4}$	½	½	½	½

Key: 1= Full irrigation water requirement applied, ½ = Half irrigation water requirement applied

Table 4: Plant heights (cm) of *Vigna unguiculata* L. as affected by water stress at different stages of growth

		Weeks of growth			
S/No	Treatments	Wk2	Wk3	Wk4	Wk5
1	NS	13.70a	24.40a	50.10a	63.10a
2	SS_1	13.80a	23.20a	39.90b	48.90b
3	SS_2	13.10a	22.40a	30.10b	47.80b
4	SS_3	12.80a	22.50a	41.20b	51.60b
5	SS_4	13.00a	22.50a	48.70a	59.80ab
6	$SS_{1,2}$	12.00a	20.60a	31.80b	46.90b
7	$SS_{1,3}$	11.40a	18.60b	28.10b	50.10b
8	$SS_{1,4}$	12.00a	23.10a	43.00b	54.60ab
9	$SS_{2,3}$	13.00a	24.60a	37.30b	49.30b
10	$SS_{2,4}$	13.00a	25.10a	38.60b	51.00b
11	$SS_{3,4}$	12.50a	23.00a	41.80b	49.90b
12	$SS_{1,2,3,4}$	9.20b	17.30b	33.00b	40.70b
	L.S.D.at 0.05	0.39	2.71	0.02	3.71

All values followed by the same letter are not significantly different at 5% level of probability.

Table 5: Numbers of leaves of *Vigna unguiculata* L. as affected by water stress at different stages of growth

		Weeks of growth			
S/No	Treatments	Wk2	Wk3	Wk4	Wk5
1	NS	111.03a	118.37a	126.19a	134.53a
2	SS_1	105.94a	112.94a	120.40a	130.96a
3	SS_2	90.05b	96.00b	102.34a	111.31a
4	SS_3	76.54b	81.60b	86.99b	94.62ab
5	SS_4	105.48a	102.40a	113.90a	127.80a
6	$SS_{1,2}$	66.62c	71.02b	75.71b	80.72b
7	$SS_{1,3}$	43.31c	46.18c	49.23c	53.54b
8	$SS_{1,4}$	90.32b	88.70bc	99.72b	104.67a
9	$SS_{2,3}$	55.38c	56.32c	60.28b	68.81b
10	$SS_{2,4}$	28.87c	30.77c	32.81c	35.69c
11	$SS_{3,4}$	24.54c	26.16c	27.89c	30.33c
12	$SS_{1,2,3,4}$	20.86c	22.23c	23.70c	25.78c
	L.S.D.at 0.05	3.49	0.08	1.94	1.63

All values followed by the same letter are not significantly different at 5% level of probability.

Table 6: Leaf area per plant of *Vigna unguiculata* L. as affected by water stress at different stages of growth.

		Weeks of growth			
S/No	Treatments	Wk2	Wk3	Wk4	Wk5
1	NS	1982.70a	2383.10a	2482.80a	2542.60a
2	SS_1	1784.43a	2144.79a	2234.52a	2288.40a
3	SS_2	1605.99a	1930.31a	2011.07a	2059.56a
4	SS_3	1088.86b	1308.75ab	1363.50ab	1396.38b
5	SS_4	1213.41b	1672.94ab	1966.38a	2242.63a
6	$SS_{1,2}$	1092.07b	1505.64b	1367.53ab	1812.42ab
7	$SS_{1,3}$	736.07c	1146.47b	1208.06ab	1223.23b
8	$SS_{1,4}$	379.64c	404.74c	431.49c	469.31c
9	$SS_{2,3}$	322.70c	344.03c	366.77c	398.92c
10	$SS_{2,4}$	274.29c	292.42c	311.75c	339.08c
11	$SS_{3,4}$	233.15c	248.56c	264.99c	288.22c
12	$SS_{1,2,3,4}$	198.18c	211.27c	225.24c	244.98c
	L.S.D.at 0.05	4.90	1.50	0.37	2.62

All values followed by the same letter are not significantly different at 5% level of probability.

Table 7: Yield and yield components of *Vigna unguiculata L.* as affected by irrigation water stresses at different growth stages

S/No.	Treatments	No. of branches /plant	Number of pod / plant	Seed weight(g) /plant	100-seed weight(g) /plant	Grain yield (t/ha)
1	NS	12.71a	14.90a	1144.72a	93.38a	3.28a
2	SS_1	11.38a	13.40a	1120.29a	89.50a	3.21a
3	SS_2	8.20b	12.50a	1040.02a	88.90a	2.98b
4	SS_3	7.34a	9.30b	492.09b	57.90b	1.41b
5	SS_4	11.63a	13.00a	1071.43a	87.90a	3.07a
6	$SS_{1,2}$	7.90b	6.84b	1019.08a	79.30a	2.92b
7	$SS_{1,3}$	5.53c	8.90b	349.00b	55.30c	1.00c
8	$SS_{1,4}$	11.15a	12.70a	736.39a	77.80b	2.11b
9	$SS_{2,3}$	4.62c	7.30b	272.22b	51.40c	0.78c
10	$SS_{2,4}$	8.04b	6.50c	589.81b	78.20b	1.69c
11	$SS_{3,4}$	3.65c	6.42c	198.93c	49.60c	0.57c
12	$SS_{1,2,3,4}$	3.50c	4.49c	153.56c	40.10c	0.44c
	L.S.D.at 0.05	0.89	1.13	2.76	9.12	8.19

All values followed by the same letter are not significantly different at 5% level of probability.

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